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(54) Apparatus for screening to remove knots from a fluid borne slurry of fibres and knots.

(57) A screening apparatus (20) removes a fluid borne pulp fibre slurry from knots which have been concentrated from a pulp processing stream. A rotating radially symmetrical screen (30) provides centrifugal screening to accept a pulp fibre slurry while an integrally connected spiral flight conveyor (17) transports knots from the inner surface of the screen to a knot discharge chamber (34) located axially above the screening chamber (62). Above the screening chamber but below the liquid level (65) in the housing (14), a fibre free wash liquid is provided through a tangentially orientated nozzle (32) in the direction of rotation of the spiral flight conveyor to release fibres from the knot surfaces thereby enabling them to pass through the screen. The screening apparatus also provides for removal of heavy tramp materials, for maintaining liquid level control, for minimizing air entrainment and foam formation, and for preventing clogging of the screen apertures and knot discharge outlet.

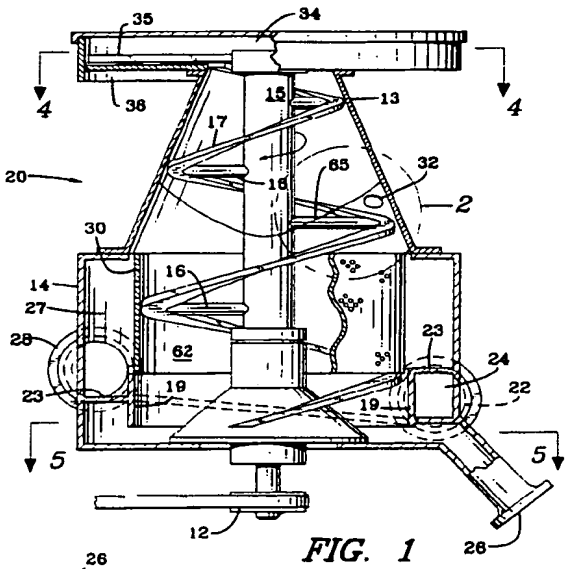

FIG. 1

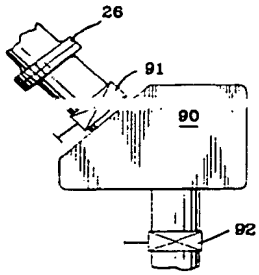

FIG. 1A

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This invention relates generally to separation of very large particles from a fluid borne stream of relatively fine particles by screening, and more particularly to coarse screening devices for washing and draining fine fibre/liquid suspension away from coarse nodules and/or other large particles.

For example in the digestion of wood for pulpmaking, a small fraction of chips become masked by other chips or are sufficiently digestion resistant to survive the digestion process and are commonly called knots. These and other undigested particles must be removed from the fluid borne pulp stream to prevent clogging of processing equipment and, ultimately, degradation of paper quality.

Removal of knots is normally accomplished in a knotter which screens the process slurry to remove them. A significant quantity of acceptable pulp is discharged along with the knots being rejected. This pulp must be separated from the knots before the knots are reprocessed or otherwise disposed of. In most cases, separation is accomplished in a knot drainer, which is a coarse screen which separates knots from pulp fibres and discharges the knots in a relatively dry and fibre free condition.

"Secondary" knot drainers, commonly consist of either high speed vibratory screens or generally vertical screw drainers. These may permit air entrainment with consequent foam generation which can adversely affect the process and require excessive defoamer consumption. In the screw type knot drainers, relative motion by the conveying screw and the screen plate can cause size reduction of the suspended particles. This "comminution" of knots can result in fibrous and resinous debris which is difficult to remove in downstream processing and which can degrade paper quality. Another consequence of using either type of secondary knot drainer may be discharge of an excessive amount of fibre with the knots. This fibre must either be recovered in further processing or be lost to production. Because of vibration and wear, maintenance costs for repair and replacement of screens and other components as well as lost production due to downtime for repairs can be unacceptably high. These and other disadvantages can reduce the efficiency of the knot removal and knot draining operation and hence increase the cost of producing clean pulp.

The foregoing illustrates limitations known to exist in present screening devices for removing coarse particles from a liquid borne fine particle slurry such as the various pulp types used in papermaking.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a diagrammatic, partly sectional, elevation of a screening apparatus for separating coarse solid particles from a fluid borne slurry,

Figure 1a shows a tramp particle accumulator and discharge arrangement of the apparatus;

Figure 2 is a fragmentary elevation taken in circled area 2 of Figure 1 showing a knot/fibre wash nozzle;

Figure 3 is a plan view from line 3-3 of Figure 2 showing more detail of the wash nozzle;

Figure 4 is a plan view from line 4-4 of Figure 1 showing a knot discharger;

Figure 5 is a plan view from line 5-5 of Figure 1 showing a grit separator;

Figure 6 is a fragmentary elevation of a knot drainer showing a level control device;

Figure 7 is a fragmentary elevation showing an optional hydrodynamic backwash pulse generator;

Figure 8 is a plan view from line 8-8 of Figure 7;

Figure 9 is a plan view of an alternative form of the pulse generator; and

Figure 10 is an elevation from line 10-10 of Figure 9.

Figure 1 shows several features of a screening apparatus in the form of a knot drainer 20. Its housing is made up of a lower cylindrical section 14, an upper extension 13 formed in this instance as a truncated cone, and a fluid free coarse particle chamber 34 at the top.

A fluid borne slurry of fine particles together with very coarse particles is tangentially fed through an inlet connection 22 and passes through a feed chamber 24 in a circular path. The feed chamber 24 is bounded by an inner wall 19, the outer housing 14 and a roof 23 which spirals downwards from the inlet 22 until it approaches the bottom of the inner wall 19 where it ends. The tangential feed path of the slurry imparts centrifugal force to the slurry and causes grit, stones, and other heavy tramp materials to be carried along at the housing wall 14 and finally to be deposited, for example, into a combined grit accumulator and discharge nozzle 26.

Since the inner walls 19 end above the bottom of the housing 14, the slurry enters the processing portion of the knot drainer by flowing under the inner wall 19. A rotor shaft 15, which extends vertically at the centre of the knot drainer in a screening chamber 62, is supported on a rotor base 11 which contains standard bearings and seals required for pulp processing equipment. The rotor is driven through sheave wheels or other drive member 12 beneath the housing 14. A screw flight 17 begins near the bottom of the inner wall 19 but more normally begins near the bottom of a substantially cylindrical screen cylinder 30 and spirals to the top of the housing extension 13. In the preferred embodiment, three flights 17 are provided, but for the sake of clarity, only one is illustrated here. The flights 17 are connected to the rotor shaft 15 through brackets 16. The screen 30, which extends axially from about the top of the inner wall 19 to slightly above the

top of the cylindrical housing 14, is firmly attached to the outer edge of the spiral flights 17. The upper portions of the spiral flights 17 turn freely relative to the truncated cone section which forms the wall of the housing extension 13. The screen 30 is dimensioned to fit very closely to the inner wall 19 and the upper flange of cylindrical housing 14 so that, although it is free to rotate relative to the walls, it is close enough effectively to prevent passage of undesirably large particles from the screening chamber 62 into an accepts chamber 27. The accepts chamber 27 is bounded on the outside by the cylindrical housing 14, on top by the upper flange of the cylindrical housing 14, on the bottom by the roof 23 of the inlet chamber 24 and on the inside partly by a portion of the inner wall 19 and partly by the cylindrical screen 30.

During operation, a vortex fluid surface 65 in the knot drainer is basically concave as illustrated. Accept pressure of the slurry is adjusted to maintain the fluid level substantially as shown above the screening chamber 62. This keeps the screen and the accepts chamber completely flooded so that foam formation will be minimised. The accepts slurry passes through the screen 30 into the accepts chamber 27 and is returned to the pulp processing stream through an accepts outlet 28. Slightly above the top of the screen 30 a nozzle 32 for introducing fibre free wash liquid is provided. A more detailed view of the area within circle 2 of Figure 1 is shown in Figure 2 while a plan view from line 3-3 of Figure 2 is presented in Figure 3. From these it can be seen that the nozzle 32 introduces the fibre free wash liquid in the direction of travel of the spiral flights 17, which are each connected through brackets 16 with the rotor shaft 15. The flights 17 describe helices of progressively decreasing diameters within the housing extension 13. This allows them to rotate freely while maintaining a very close proximity to the housing extension 13.

The housing extension 13 is preferably provided in the truncated cone shape illustrated although a straight cylindrical form is also possible. This provides the advantages of a steep contact angle between the fluid surface 65 and extension wall 13 which prevents liquid spillage into the knot discharger 34, reduces turbulence and foam formation, and improves drainage of knots on the flights 17 above the fluid surface 65. This improves elutriation performance of the nozzle 32 and thus provides higher knot draining efficiency.

The knot discharger 34 is shown at the top of the knot drainer 20. It consists of a flat annular surface 38 attached at the top of the housing extension 13. The rotor shaft 15 and flights 17 extend into the discharger where knots, as they arrive from the flights, are swept around the surface 38 and outwards to a discharge outlet 36 by sweeper bars 35 (Figures 1 and 4).

Figure 5 shows the opening of the discharge nozzle 26 for grit, stones, metal and other heavy tramp material. The lower extremity of the inner wall 19 is shown. As seen in Figure 1, this member ends some distance above the bottom of the housing 14 to permit entry of the feed slurry into the screening chamber 62. The shadow of the inlet 22 is shown to indicate the relative location of the discharge nozzle 26 with respect thereto. The area outside the inner wall 19 is the extension of the feed chamber 24 which would be seen once the spiral roof of the feed chamber 24 has reached the bottom of the inner wall 19. Because of the higher density of the tramp metal, stones and grit particles, they are vigorously thrust outwards by the centrifugal force imparted by the downward spiralling inlet flow. This causes them to pass into and accumulate into the discharge nozzle 26 above a normally closed valve 91, as shown in Figure 1a. Periodically, a valve 92 is closed and the valve 91 is opened to release the particles from the nozzle 26 allowing accumulated tramp particles to fall into a tramp particle accumulator 90. Then the valve 91 is closed and the contents of the accumulator 90 may be dumped by opening the valve 92. Also shown in Figure 5 is the rotor base 11, rotor shaft 15, one of the support brackets 16 and the beginning of one of the spiral flights 17 which may be coextensive with the bottom extremity of the inner wall 19. Employment of the tramp particle accumulator 90 of Figure 1a is an optional embodiment, as there may be preferable discharge means other than the two valve trap shown.

Figure 6 shows an optional level control system for use with the present apparatus. It includes a downward extension of the stationary truncated cone housing extension 13. This downward extension acts as a vortex breaker 40 and is approximately axially coextensive with the screen 30. It is shown in the figure as a perforated plate but it may also be provided with vertical slots. With either holes or slots, the vortex breaker 40 substantially eliminates the tangential flow of the accepts slurry and leaves only the radial component of flow. A level control weir 45 separates the accepts chamber 27 from a vortex chamber 42a and a radial flow chamber 42b. As the slurry flows over the weir 45 from the radial flow chamber 42b, it pours over and through an anti-splash baffle 47 into the accepts chamber 27. The baffle 47 reduces air entrainment by further reducing the turbulence of the slurry flow. A vent 50 is provided at the top of a level control chamber 49 to permit escape of any air released from the slurry.

Figures 7 to 10 illustrate two embodiments of a backwash device which is provided to prevent occlusion of the apertures of the screen 30 by knots and other coarse particles.

The embodiment shown in Figures 7 and 8 consists of a hydrodynamic foil 80 which is axially coextensive with and positioned outboard of the screen 30 and in close radial proximity thereto. As the rotating screen 30 passes the foil 80 the fluid borne slurry between them receives a pressure pulse which

backwashes the screen apertures to expel knots which may otherwise plug the apertures.

An alternative embodiment of the hydrodynamic foil 82 is shown in Figures 9 and 10. In this case, the foil 82 consists of an overhang 83 and two "heels" 84. Between the heels 84 is a passage 85 through which the accepts slurry together with small coarse particles can escape. The geometry of the foil 82 causes it to act like a flat fluid collection funnel with its inlet bounded by the overhang 83 and screen 30 and its outlet 85 defined by the heels 84 and screen 30. The standoff distance of the overhang 83 from the screen 30 is approximately the same dimension as the diameter or width of the screen apertures. This ensures that small coarse particles which pass through the screen will not collect and jam between the foil 82 and screen 30.

Operation of a knot drainer, including all features described and illustrated, begins with introduction of the knot containing pulp slurry at the inlet connection 22. From there it passes through the inlet chamber 24 bounded by the inner wall 19, cylindrical housing 14 and spiral roof 23. Centrifugal force generated by the tangential inlet and the confined circular flow path of the slurry causes heavy tramp particles to be segregated at the outer boundary of the feed chamber 24 and to pass into the nozzle 26 and thence through the valve 91 when open into the tramp particle accumulator 90 or other tramp particle accumulation system. The knot bearing pulp slurry, meanwhile, flows beneath the inner wall 19 and upwards into the screening chamber 62. At the bottom of the inner wall 19, the fluid borne slurry encounters the spiral flights 17 which act as a screw conveyor to carry knots and pulp upwards into the screening chamber 62. The screening chamber 62 is that volume bounded by the rotating cylindrical screen 30. The accepts chamber 27 is radially outboard of the screen 30 and is drained through the accepts discharge nozzle 28. The spiral flights 17 and rotating cylindrical screen 30 are firmly attached so that they rotate together. Rotary motion is transmitted from the rotor shaft 15 to the spiral flights 17 through the support brackets 16. The knot bearing pulp slurry is screened by the apertures in the screen 30 so that most of the accepts slurry is separated from the knots which are transported on the rotating flights 17 through the screening chamber 62.

The pressure pulsations induced in the screen apertures as they pass the pulse inducer 80 or 82 expel fibre plugs to maintain flow through the apertures and also expel knots so that they continue their transport along the rotating flights 17. The fluid surface 65 is concave due to the centrifugal forces imparted by the rotor. Slightly above the screening chamber 62 but below the liquid surface 65, the nozzle 32, tangentially fixed in stationary housing extension wall 13, introduces the substantially fibre free liquid to release fibres from the reject knots. This liquid is introduced in the same direction as the rotation of the flights 17 in order to minimise turbulence and energy consumption and to prevent air entrainment. The fibres thus released are carried downward through the screening chamber 62 and pass into the accepts chamber 27. The knots are transported upward on the rotating flights 17 by the drag of the knots on the inclined stationary wall 13. Once above the liquid surface 65, the knots quickly drain to a relatively dry condition as they are carried upward to discharge chamber 34. In one embodiment, knots are deposited on the flat annular surface 38 of the discharger and are impelled by the discharger sweeper arms 35 and carried around and outward to the knot discharger nozzle 36 where they are expelled in a substantially fibre free and relatively dry condition.

In cases where the level control feature is included, the fluid level in the knot drainer will be determined by the height of the level control weir 45. Acceptable pulp slurry passes through the rotating cylindrical screen 30, into the vortex chamber 42a, through the vortex breaker plate 40, which has a thickness greater than the width of its apertures such that substantially all of the tangential component of flow is suppressed and only the radial component remains, and into the radial flow chamber 42b. The slurry thus flows smoothly over the weir 45 and into the accepts chamber 27 by passing over and through the anti-splash baffle 47. The combination of the weir and the anti-splash baffle reduces air entrainment by limiting turbulence so that foaming is minimised and the pulp slurry discharge through accepts discharge nozzle 28 requires little if any defoamer. At the top of level control chamber 49 is vent 50 which is provided to permit the exit of any air released from the pulp slurry within the chamber.

The screen backwash function described herein could be performed by one or more slotted nozzle through which fibre free liquor is introduced, but that can cause unacceptable dilution. Hence, the hydrodynamic pulse inducers are preferably for that purpose.

Provision of a rotating radially symmetrical screen, whether conical or cylindrical, integrally connected to the spiral flight conveyor, eliminates a source of often severe damage in knotters and knot drainers of standard configuration. Stones or other hard tramp particles which enter the screening chamber of a standard knotter or knot drainer are very likely to lodge between the stationary screen and the moving rotor or hydrofoil causing severe wear and damage to both members. In the present apparatus, stones or hard tramp particles that may escape the grit and tramp particle discharge provision will be carried upward on the spiral flights, but, since there is no relative motion between the flights and the screen, the particles will merely roll or slide along the screen surface without any grinding or jamming behaviour. Con-

tinuation of the spiral flight above the liquid level of the knot drainer permits discharge of substantially dry fibre free knots and a consequent reduction in the amount of reprocessing necessary.

Claims

1. A screening apparatus (20) for separating coarse solid particles from a fluid borne slurry, comprising:

   a housing (14) having a feed chamber (24) located near a bottom of said housing for receiving a fluid borne suspension of fine and coarse solid particles; characterised by:

   a screening chamber (62) within said housing above and in communication with said feed chamber (24) and bounded by a rotatable screen (30) which in use has a vertical axis and is fully immersed in the slurry;

   a fine particle accepts chamber (27) located within said housing radially outboard of said screen (30) and having a fine particle accepts outlet (28);

   a substantially fluid free coarse particle discharge outlet (36) located at the upper end of said housing in communication with said screening chamber below; and

   means (15, 17) associated with said screen for transporting said coarse particles upwards through said screening chamber to said coarse particle discharge outlet.

2. An apparatus according to claim 1, wherein a fluid free coarse particle discharge chamber (34) communicates with the screening chamber through a stationary housing extension (13) located above said screening chamber and below said discharge chamber.

3. An apparatus according to claim 1 or 2, wherein said transporting means comprises at least one rotatably-supported, spiral flight (17) connected to said screen.

4. An apparatus according to claim 3, wherein said spiral flight extends above said screen, which is cylindrical, and is closely bounded by said stationary housing extension (13) and the coarse particle discharge outlet (36) is located within said coarse particle discharge chamber (34).

5. An apparatus according to claim 4, wherein said spiral flight and said stationary housing extension have truncated conical forms which taper inwardly towards an opening through which coarse particles are fed into said coarse particle discharge chamber portion of said housing.

6. An apparatus according to any one of the preceding claims, further comprising a tangentially orientated fluid inlet nozzle (32) near an outlet portion of said screening chamber for introducing substantially fibre free liquid near a liquid/air interface (65) above said screening chamber for releasing said fine particles from said coarse particles.

7. An apparatus according to claim 6, arranged so that the substantially fibre free liquid is, in use, introduced in the direction of rotation of said transporting means.

8. An apparatus according to claim 2 or any one of claims 3 to 7 as appendant to claim 2, wherein the coarse particle discharge chamber (34) further comprises a radially extending annular surface providing communication from said transporting means to said coarse particle discharge outlet (36) and means (35) for sweeping said radially extending annular surface for urging said coarse particles into the coarse particle discharge outlet.

9. An apparatus according to claim 8, wherein the means (35) for sweeping the radially extending annular surface comprises a portion of a rotatably supported shaft (15) extending into said coarse particle chamber (34) and at least one radially projecting rotatable bar (35) connected to said shaft so as to sweep over and in close axial proximity to said radially extending annular surface.

10. An apparatus according to any one of the preceding claims and further comprising means (90, 91) for removing grit, stones, metal and other tramp material from the pulp slurry prior to screening.

11. An apparatus according to claim 10, wherein the means for removing grit, stones, metal and other tramp material comprises a tangentially arranged slurry inlet nozzle (22), a feed chamber (24) having an approximately 360° circumferential extent and in fluid communication with said slurry inlet nozzle, means for at least maintaining the tangential velocity of the feed slurry, a grit discharge nozzle (26) projecting through the housing (30) downwardly and outwardly from the lower outer edge of the feed chamber and a tramp particle accumulator (90).

12. An apparatus according to claim 11 and further comprising means (92) for removing accumulated grit, stones, metal and other tramp material from said tramp particle accumulator (90).

13. An apparatus according to any one of the preceding claims and further comprising means for con-

trolling the liquid level in said screening apparatus.

14. An apparatus according to claim 13, wherein the means for controlling the liquid level comprises a top vented liquid level control chamber (42) radially outboard of the rotating screen (30), means (40) for substantially eliminating the tangential component of fluid flow in a vortex reduction section (42b) of the liquid level control chamber, a weir (45) radially outboard of the vortex reduction section for establishing a liquid level limit and means (45, 47) for reducing fluid turbulence and air entrainment.

15. An apparatus according to any one of the preceding claims and further comprising means (80 or 82) for creating a backwash fluid flow sequentially through successive vertical rows of apertures in the rotatable screen (30).

16. An apparatus according to claim 15, wherein the means for creating the backwash fluid flow comprises at least one stationary hydrodynamic pulse generating device (80 or 82) placed in close proximity to a circumferential surface of the rotatable screen, which is radially symmetrical.

17. An apparatus according to any one of the preceding claims and being in the form of a knot drainer for separating acceptable pulp fibres from knots in a fluid borne slurry, wherein said feed chamber located near the bottom of said housing is for receiving a fluid borne suspension of knots containing acceptable pulp fibre and said substantially fluid free coarse particle discharge outlet is for discharging knots.

18. An apparatus for generating hydrodynamic pulses, in a substantially cylindrical vertically orientated screening device for wood pulp processing, comprising a rotating open-bottom screen (30) fully immersed in a fluid; and a rigid member (80 or 82) positioned parallel to and in close proximity to said screen.

19. An apparatus according to claim 18, wherein said rigid member comprises a substantially rectangular plate (84) having its length dimension transverse to the direction of relative motion between said rigid member and said screen and coextensive with a directionally transverse dimension of said screen.

20. An apparatus according to claim 19, wherein the plate comprises a leading overhang portion (83) having a reduced thickness which, together with said screen surface, defines a fluid collection gap of a thickness which is proportional to the apertures of said screen; and a trailing portion having two heel regions (84) of a thickness also proportional to the apertures of said screen, said regions being separated by a passage (85) which is an extension of said fluid collection gap so that said overhang, heels, and passage define a flat funnel in conjunction with said screen surface.

21. An apparatus according to claim 20, wherein said trailing portion of said rigid member has two heel regions which are so contoured as to define a constant narrow gap in conjunction with said screen.

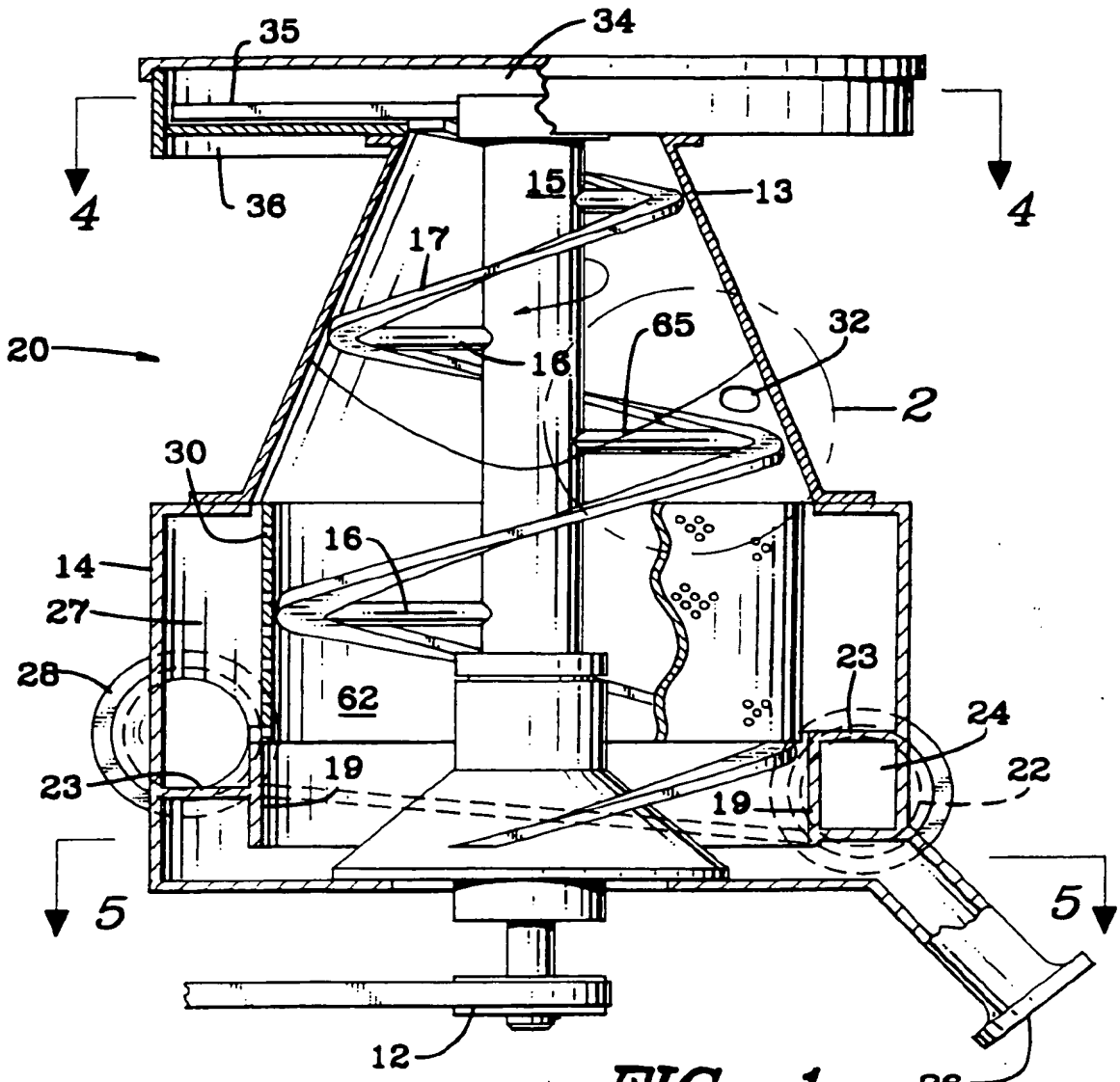
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FIG. 1

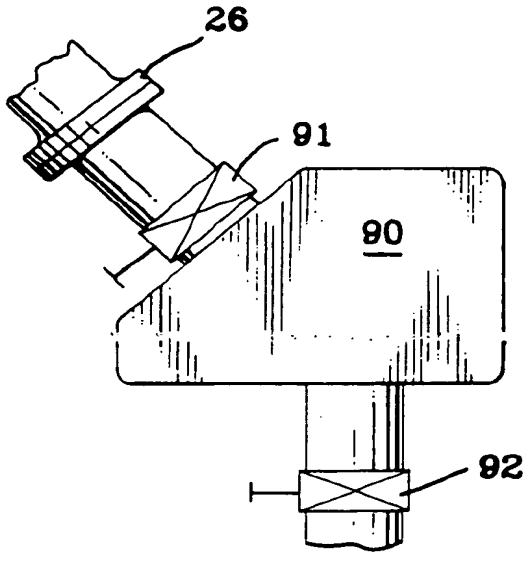
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FIG. 1A

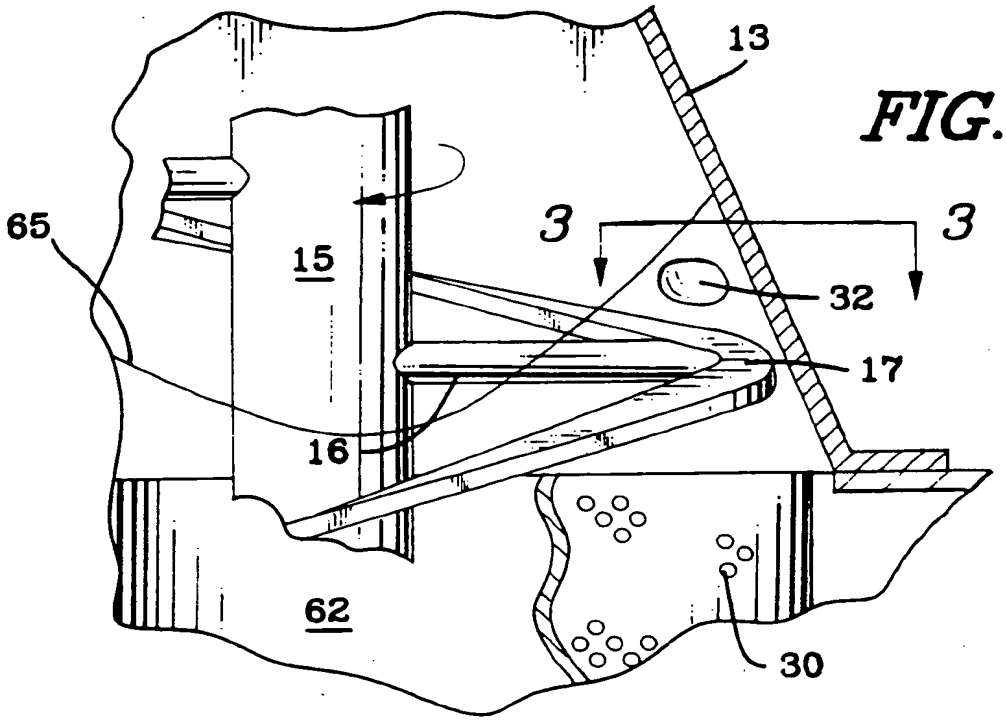


FIG. 2

FIG. 3

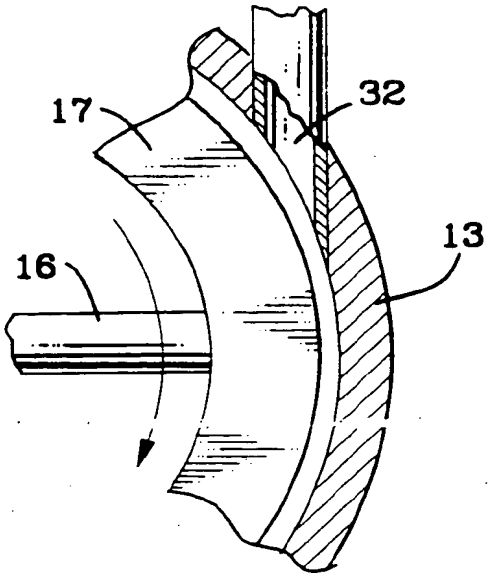
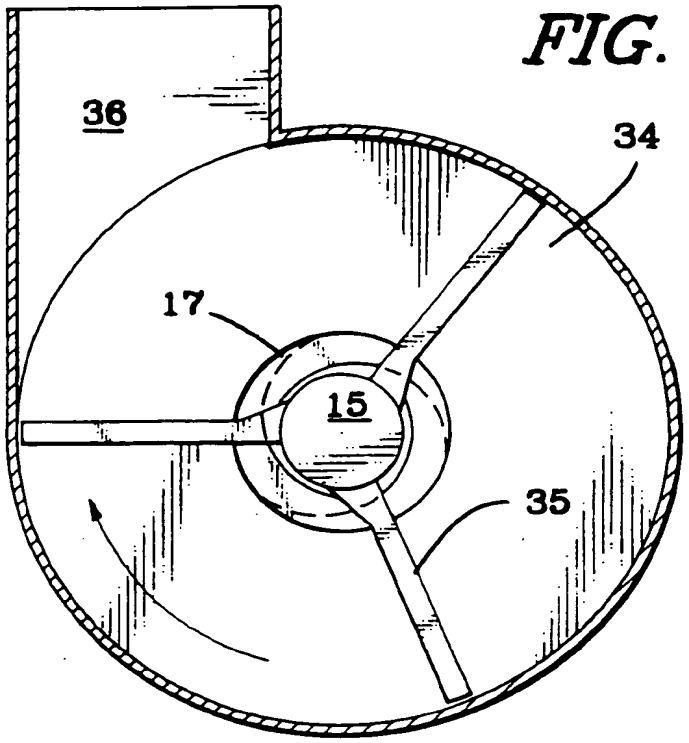


FIG. 4



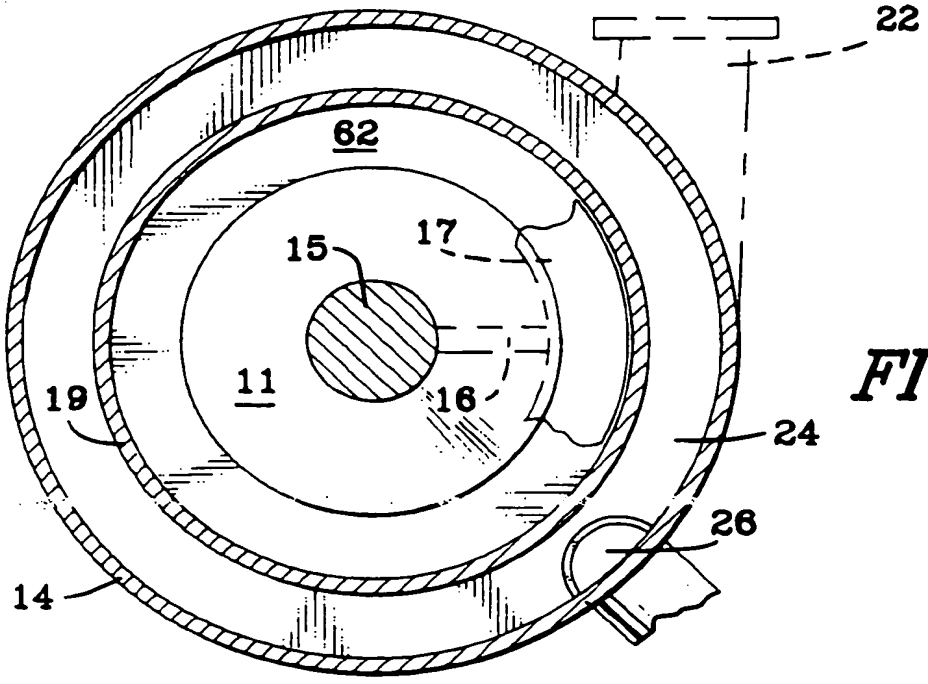


FIG. 5

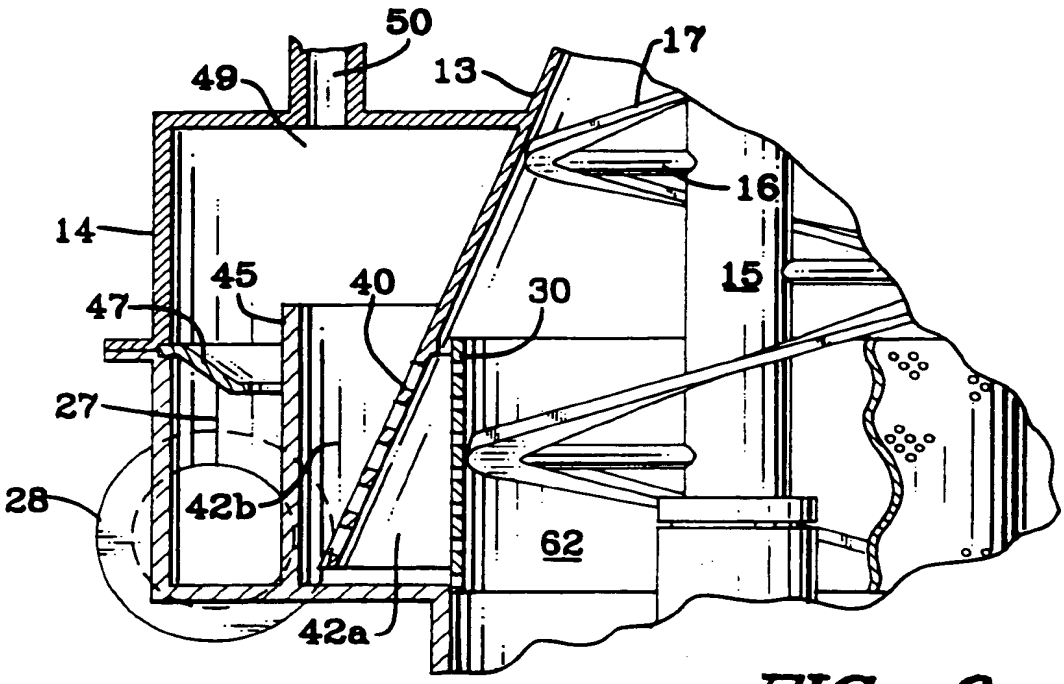


FIG. 6

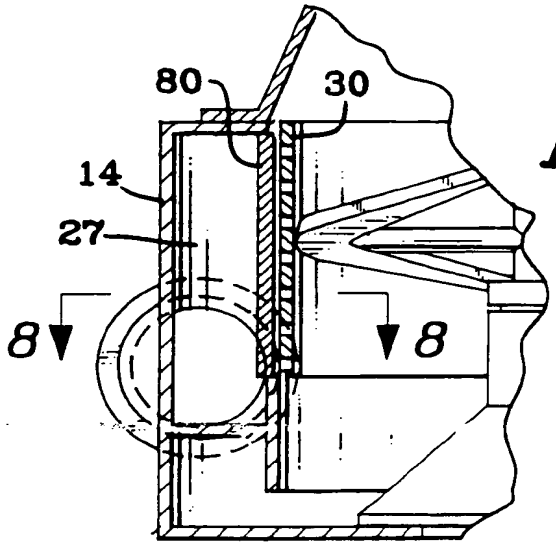


FIG. 7

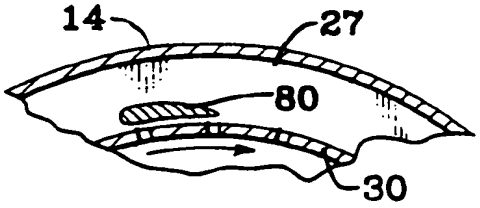


FIG. 8

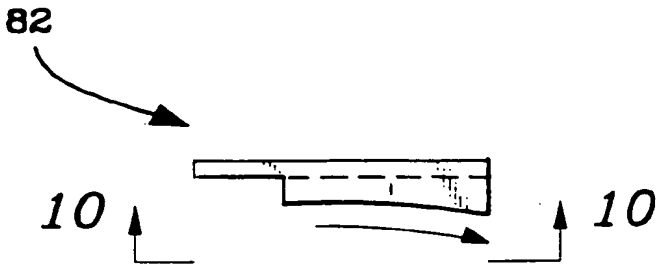


FIG. 9

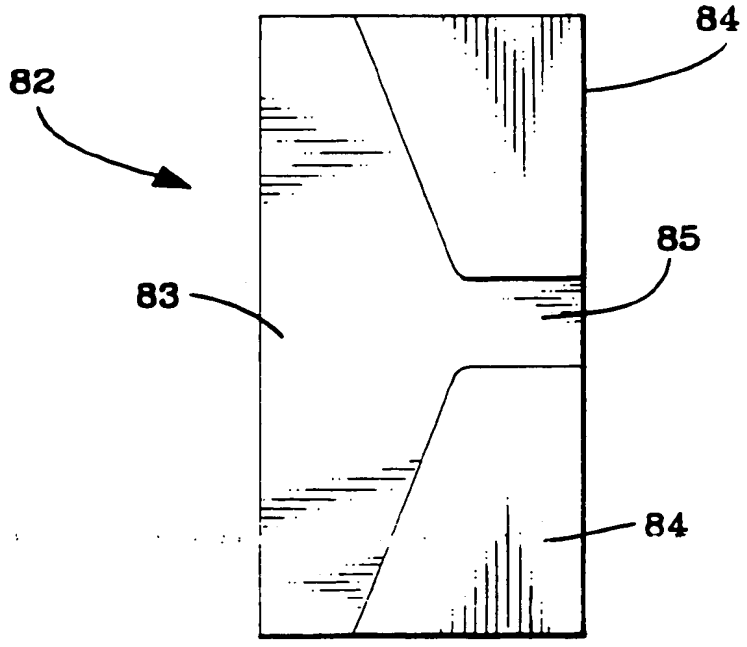


FIG. 10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0199

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 036 328 (THE BLACK CLAWSON COMPANY) * page 3, line 35 - page 8, line 13; figure 1 *	1-3,17, 18	D21D5/02 D21D5/06
A	EP-A-0 253 006 (HERMANN FINCKH MASCHINENFABRIK GMBH) * the whole document *	1,2,5	
A	GB-A-2 067 911 (AB CELLECO) * the whole document *	6-9,15, 16	
A	US-A-3 317 051 (RANHAGEN ET AL.) * the whole document *	1,3,4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			D21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 FEBRUARY 1992	ELMEROS C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EPO FORM 1503 03.82 (P0400)